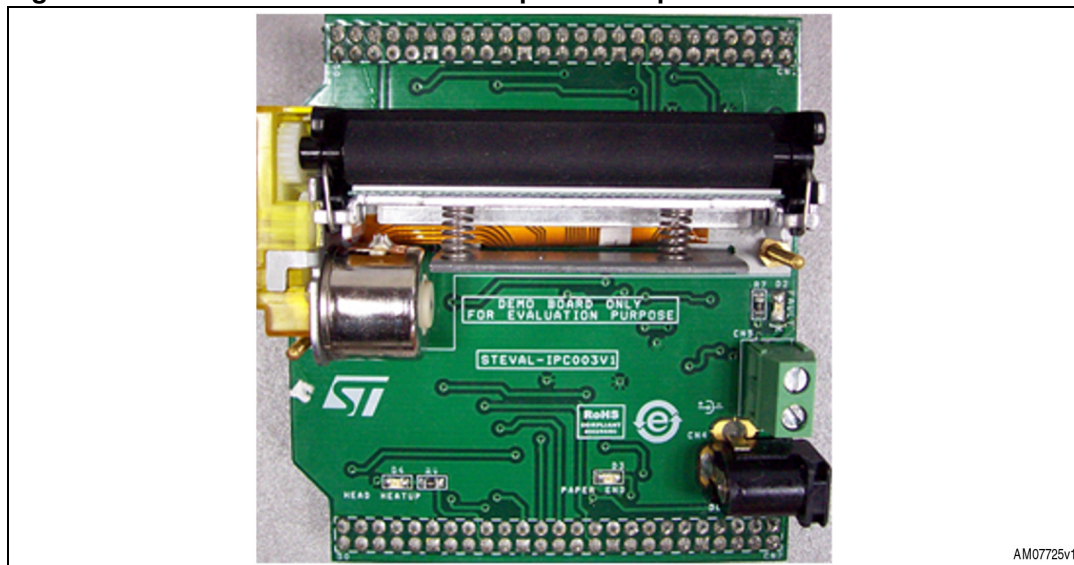


### Thermal printer adapter board for the STM3210C-EVAL

#### Introduction

The thermal printer adapter board for the STM3210C-EVAL is an addition to the solution of parking ticket vending machines. This daughter board is interfaced with a Connectivity line Demonstration Board, using the touch-based TFT as the user interface keypad. The objective of this demo is to print and generate parking tickets for different types of vehicles as well as printing text messages received over the ethernet. It is an application which can be reused in PoS based applications. Paper feed is done by a stepper-motor, for which a driver is required. The driver, used for the stepper-motor (L293DD), has a push-pull four-channel driver with diodes. The signals are manually changed across the input ends of the driver, in a particular sequence according to the timing diagram of the stepper motor, and the motor rotates. A connector for the DC power adaptor is provided and the EVAL board is powered up using the supply from the daughter board. This is done by setting the jumper position on the EVAL board. The data to be printed is entered through the touchscreen based keypad on the TFT; data entered is also displayed on the TFT screen.

**Figure 1. STEVAL-IPC003V1: Thermal printer adapter board for STM3210C-EVAL**



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# 1 Features

The key features of the application are:

- Designed for connectivity line Eval board
- Thermal printer is interfaced through SPI3
- Stepper motor driver (L293DD) interfaced through GPIOs of STM32 to rotate the printer head while printing
- The touchscreen on the TFT is used for touch detection for key pad data entry
- QVGA color TFT available on the STM3210C-EVAL board is also interfaced through SPI3 to display the touch-based key pad and user entered data
- The complete package demonstration board and daughter board needs a single power supply input of 5 V. Change the jumper position on the demonstration board to daughter board power supply and connect a 5 V DC adapter to the connector provided on the daughter board
- ADC analog watchdog is used to monitor the temperature of the thermal head
- RTC (real time clock) provides the date and time of printing

## 2 Getting started

### 2.1 Package

The Thermal printer adapter board for the STM3210C-EVAL includes the following items:

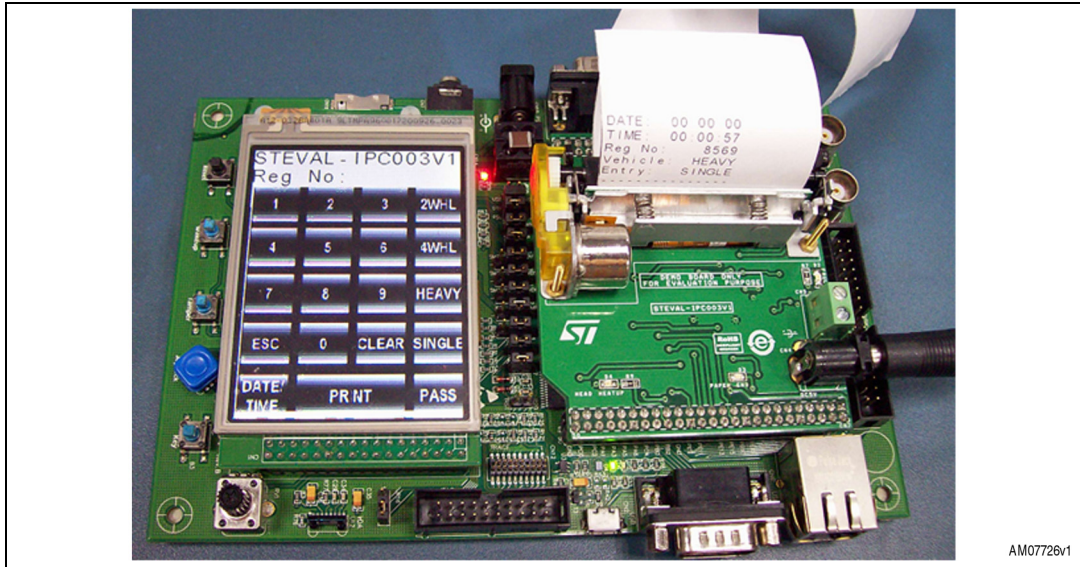
- Hardware content:
  - Demonstration board: STEVAL-IPC003V1
- Documentation:
  - User manual (this document)
  - Schematics, Gerber files, BOM list
- Firmware:
  - Pre-programmed STM32 device soldered onto the demonstration board
  - Object files are also available for the firmware

### 2.2 System set up

The thermal printer adapter board for the STM3210C-EVAL can be set up as follows:

- Connect the 5 V DC adapter across the connector provided on the daughter board. Change the jumper position of JP25 to DTB (daughter board power source) on the STM3210C-EVAL board
- Add thermal paper (48mm to 52 mm) to the printer head, as shown in [Figure 3](#). Keeping in mind that the printing side is the glossy side of the paper
- Now the user can see a welcome message on the TFT screen
- Then the user must enter the last 4 digits of the vehicle's registration number by pressing the corresponding numeric keys on the TFT screen
- Choose the vehicle type by pressing one of the keys: 2 WHL, 4 WHL, or HEAVY
- After selecting the vehicle category, the chosen category is displayed on the TFT for some time and it then asks for the entry type
- Entry type can be chosen by pressing one of the options: SINGLE or PASS
- After selecting the entry type, the chosen entry type is displayed on the LCD for some time
- Now the user has to give the print command by pressing the PRINT key
- The ticket is now generated
- Time can be set by pressing the DATE/TIME key

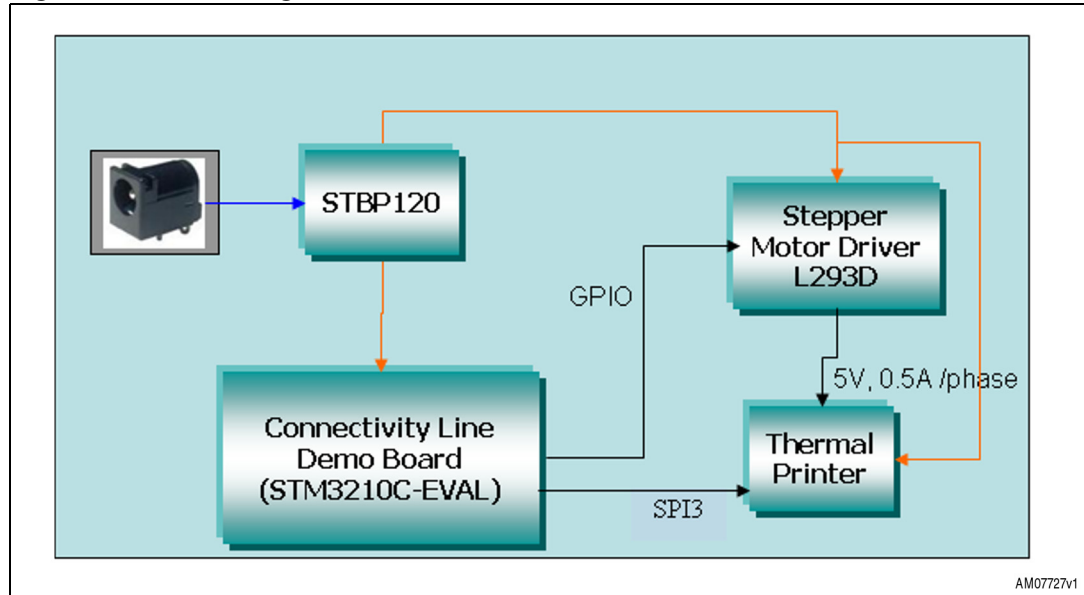
Figure 2. STEVAL-IPC003V1 mounted on the STM3210C-EVAL



### 3 System overview

#### 3.1 Hardware design description

Figure 3. Block diagram



##### 3.1.1 STM3210C-EVAL board

This application uses some peripherals such as SPI3, ADC, etc., and a few GPIOs. To use these it is necessary to remove some resistors from the STM3210C-EVAL board, to separate them from their default function. These resistors can be found in [Table 1](#):

Table 1. Pre-requisites to be applied on the STM3210C-EVAL

Action	IO required	Function of IO
JP22 open	For PC7 and PD2	Control motor winding
Remove R168	For PB1 and PB2	Strobe for printer STB4 and STB5
Remove R139	PE15	Paper end LED
Remove R167	PB0	Head heat up LED
Remove R165	PC0	ADC pin for head heat up detection

##### 3.1.2 Thermal printer (FM205-HS)

The thermal printer mechanism is a compact, high-speed thermal line dot printing mechanism. It can be used with a measuring instrument and analyzer, a POS, a communication device, or a data terminal device.

As the FM205-HS thermal printer mechanism can be driven by battery, it can be easily mounted on a portable device such as a handheld terminal.

Paper is fed in a forward direction when the motor shaft is rotating in the normal direction (clockwise), as seen from the motor gear side. The motor is driven by a 2-2 phase excitation constant current chopper method and feeds paper by 0.125 mm (equivalent to a single dot pitch) every two steps of the motor drive signal. It is not possible to print while the motor is rotating in the reverse direction.

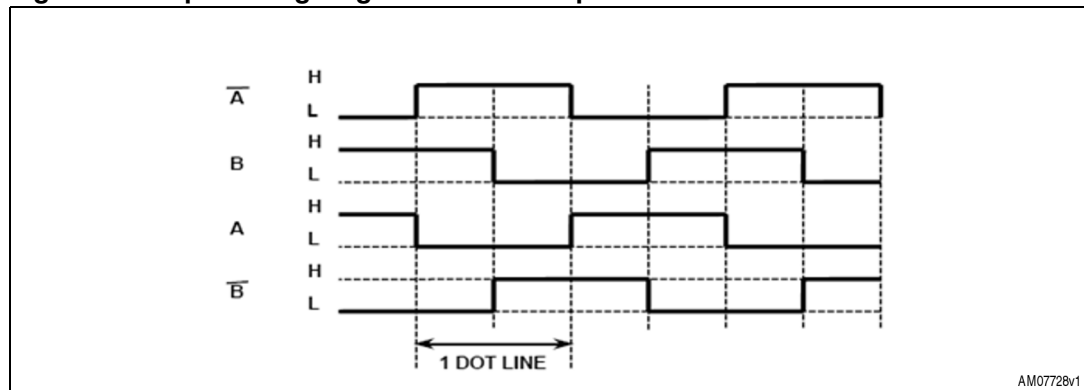
Excitation sequence:

As shown in [Table 2](#), the printer feeds the paper in the normal direction when the motor is excited in the order of step 1, step 2, step 3, step 4, step 1, step 2, etc. On the other hand, to rotate the motor in the reverse direction, the motor is driven in the reverse order of step 4, step 3, step 2, step 1, step 4, step 3, etc.

**Table 2. Truth table for excitation sequence**

Signal name	Sequence			
	Step1	Step2	Step3	Step4
A'	Low	High	High	Low
B	High	High	Low	Low
A	High	Low	Low	High
B'	Low	Low	High	High

**Figure 4. Input voltage signals for the sample drive circuit**



**Pin mapping of a printer module:**

Pin mapping for the thermal printer is normally generic. In [Table 3](#) the generic pin configurations are shown with their functions.

**Table 3. Pin mapping of thermal printer module**

Signal name	Function	Comments
PCA	Photo sensor cathode pin	Used for paper end detection
PCO	Photo sensor anode/collector pin	Used for paper end detection
PEM	Photo sensor emitter pin	Used for paper end detection
NC	Not connected	



**Table 3. Pin mapping of thermal printer module (continued)**

Signal name	Function	Comments
NC	Not connected	
VH	Dot-line voltage	
VH	Dot-line voltage	
DIN	Serial data in	SPI data in
CLK	Serial data clock	SPI clock
GND	Ground	
GND	Ground	
STB6	6th printing strobe	dots 321 to 384
STB5	5th printing strobe	dots 257 to 320
STB4	4th printing strobe	dots 193 to 256
VDD	Logic voltage	5 V
TM	Thermister 1st terminal	Used for overheat detection
TM	Thermister 2nd terminal	Used for overheat detection
STB3	3rd printing strobe	dots 129 to 192
STB2	2nd printing strobe	dots 65 to 128
STB1	1st printing strobe	dots 1 to 64
GND	Ground	
GND	Ground	
\LAT	Serial data latch	Active low
DO	Serial data out	SPI data out
VH	Dot-line voltage	
VH	Dot-line voltage	
PH1	Stepping motor 1st phase, 1st pin	A (see <a href="#">Figure 5</a> )
\PH1	Stepping motor 1st phase, 2nd pin	A' (see <a href="#">Figure 5</a> )
PH2	Stepping motor 2nd phase, 1st pin	B (see <a href="#">Figure 5</a> )
\PH2	Stepping motor 2nd phase, 2nd pin	B' (see <a href="#">Figure 5</a> )

### 3.1.3 TFT

A 3.2" QVGA color TFT with resistive touchscreen is used as the user interface, to show the keypad and the information entered by the user. This TFT is available on the STM3210C-EVAL board which is using SPI3 to communicate with the microcontroller.

### 3.1.4 Touchscreen based keypad

A resistive touchscreen on the TFT is used to detect the key pressed. Therefore, this touchscreen acts as the data input source.

### 3.1.5 Power supply unit

A 5 V DC adapter is attached to the connector on the daughter board and this power supply is then provided through a protection device, the STBP120AVDK6F, to ensure the input voltage range is within the required limits. In this case, if the DC adapter voltage is above 6.02 V, there is no output and the whole system remains in shutdown mode. Otherwise, power is transferred to output and the system stays in the ON condition. Make sure that jumper JP25 on the STM32F10C-EVAL board is in the DTB (daughter board power source) position.

### 3.1.6 Command description

- Process print command: thermal printer starts printing the data stored
- Process set date command: the date and time of the system is modified
- Process entry command: entry type, Pass or Single, is stored in the user buffer data on the basis of the touch byte
- Process vehicle command: vehicle type, car, scooter, or heavy is stored in the user buffer data on the basis of the touch byte
- Process number command: the last 4-digits of the vehicle number entered by the user are stored

## 3.2 Hardware layout

The thermal printer adapter board for the STM3210C-EVAL is built using the following components. *Figure 5* and *6* below show the component layout, to help the user locate different components/sections on the board.

The thermal printer adapter board for the STM3210C-EVAL includes the following components:

- TM32F10C-EVAL board
- FM205-HS (thermal printer)
- L293DD (stepper motor driver)

**Figure 5. Hardware layout, main board: top side**

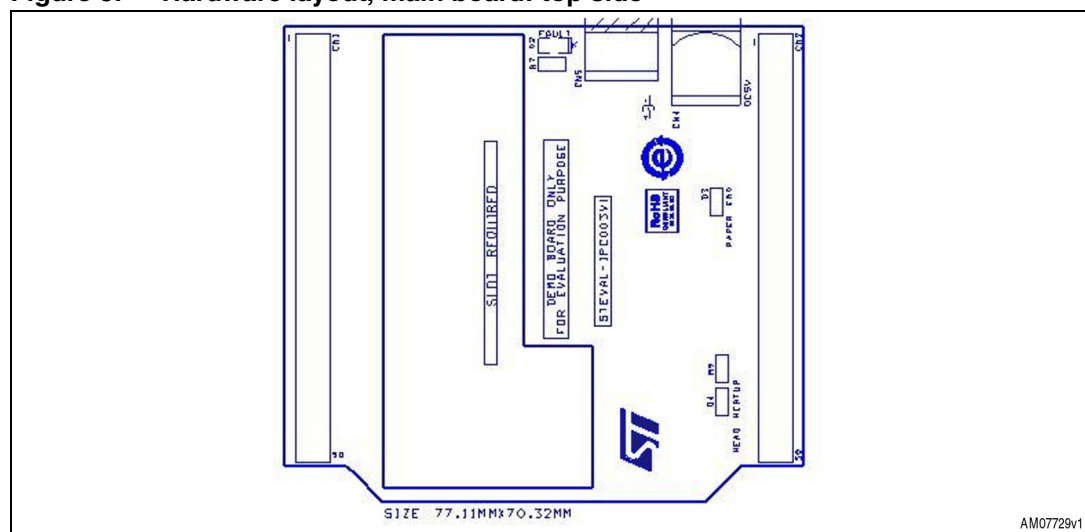
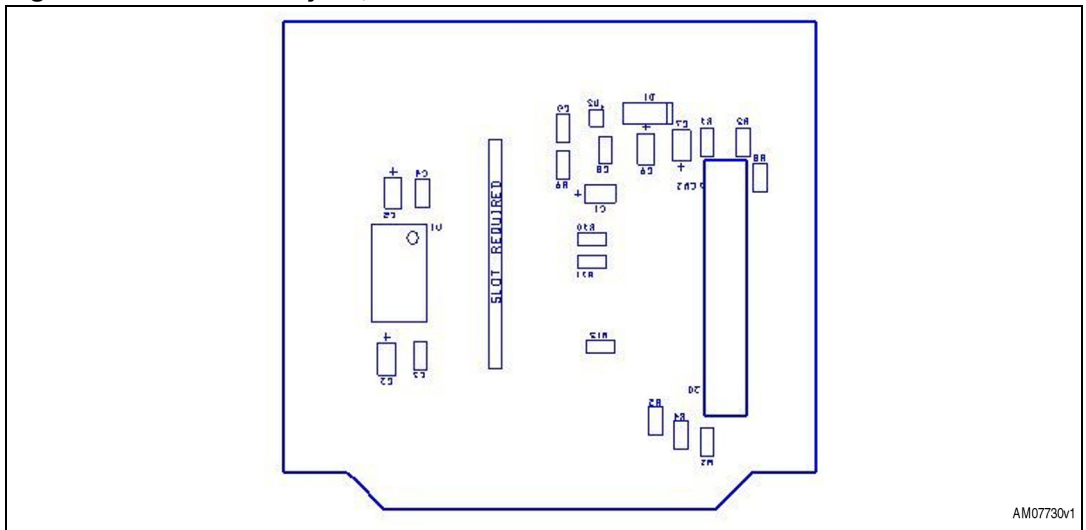


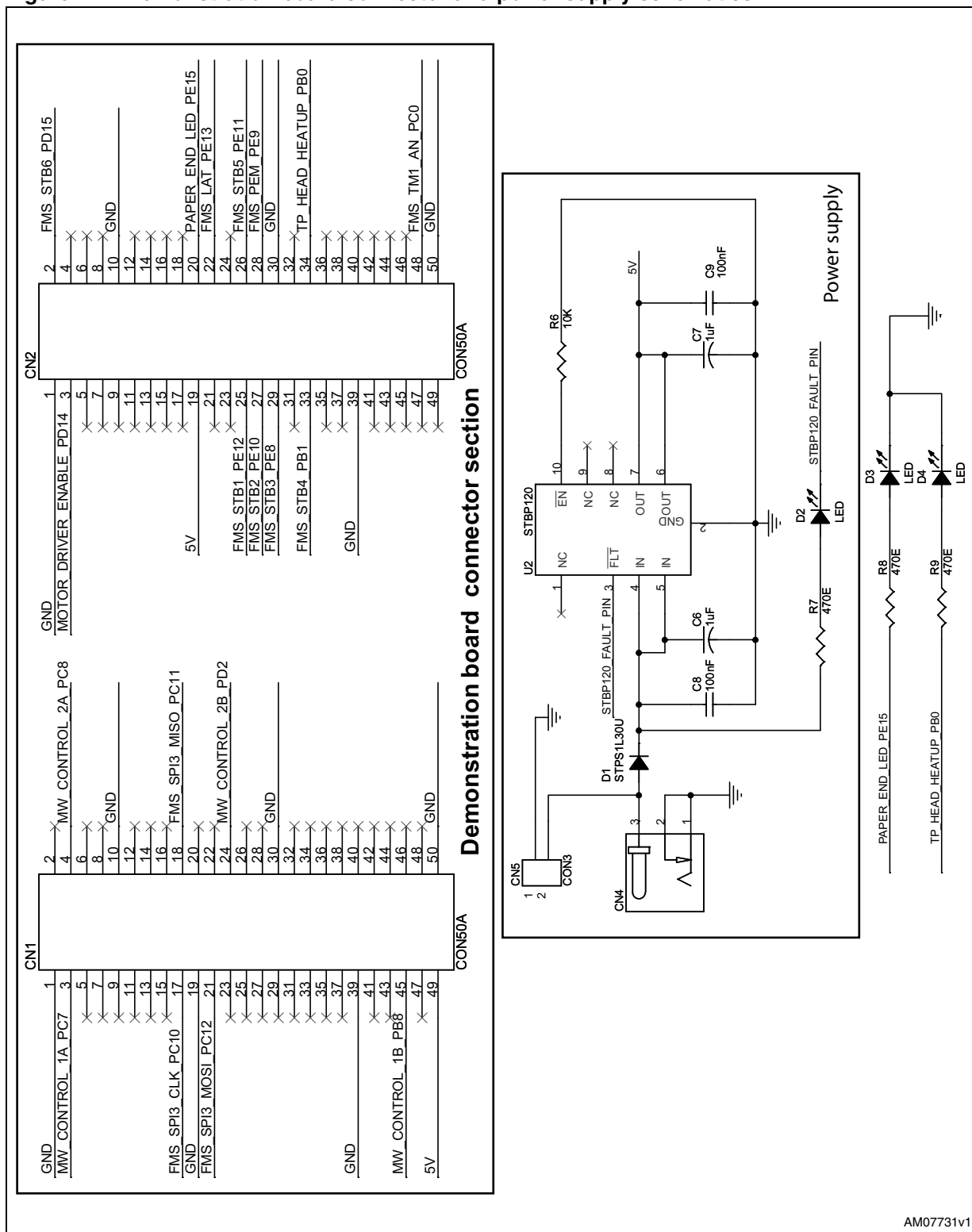
Figure 6. Hardware layout, main board: bottom side



### 3.3 Hardware schematic

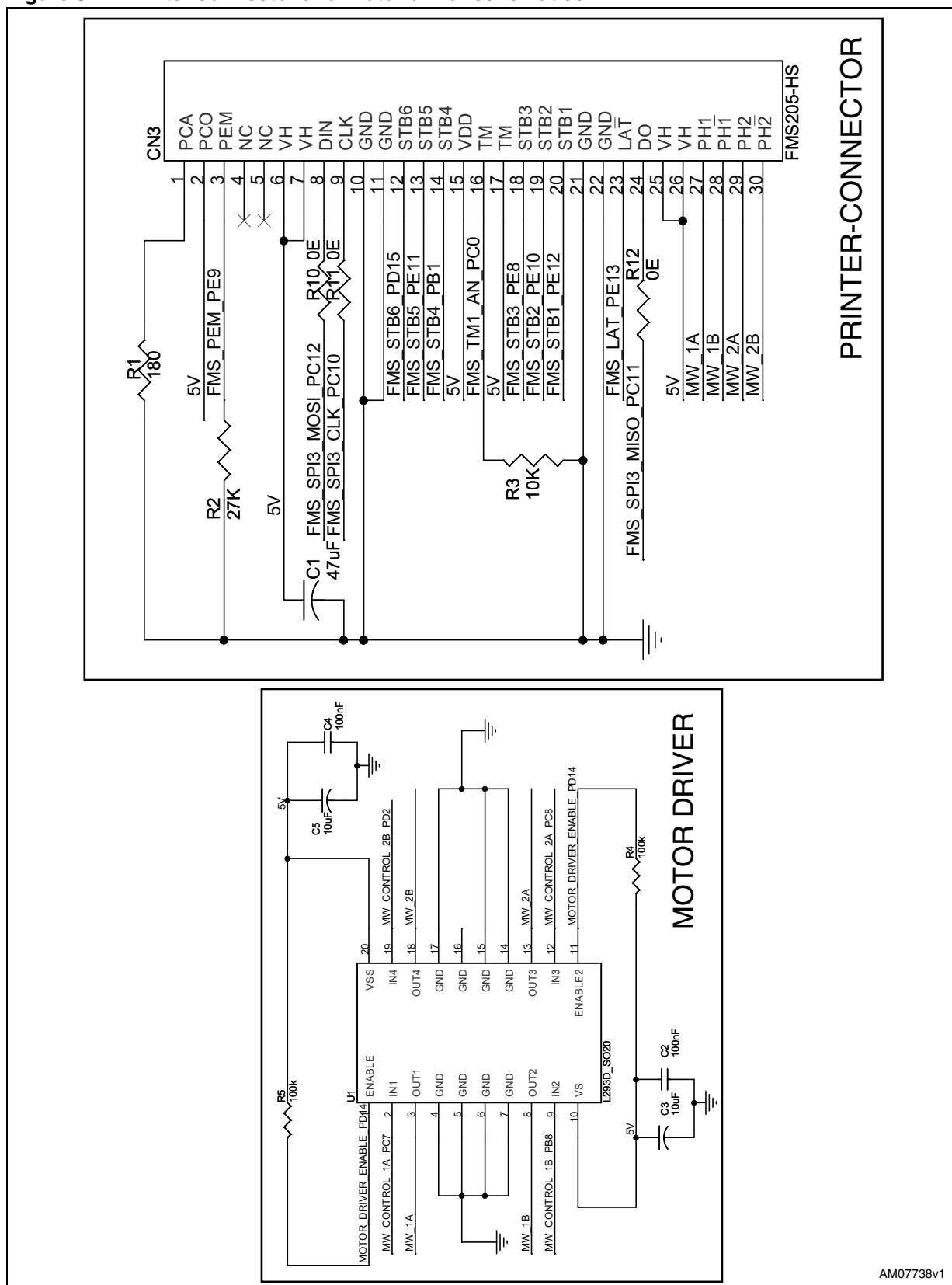
Figure 7 and 8 represent the schematic diagrams for the board.

Figure 7. Demonstration board connector and power supply schematics



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Figure 8. Printer connector and motor driver schematics



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### 3.4 BOM list

Table 4. BOM list

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
ST devices	U1	Push-pull four channel driver with diodes	SO-20	STMicroelectronics	L293DD		
	U2	Protection device (cutoff voltage 6.02 V)	TDFN – 10-lead (2.5 x 2 mm)	STMicroelectronics	STBP120AVDK6F		
	D1	STPS1L30U	SMB				
Connector	CN1,CN2	Socket, 2.54 mm, double row, machine spring contact/formed contact	Socket, 2.54 mm, double row, machine spring contact, (or Formed Contact) through hole, straight, 2x36 way	Protectron	P9303-50-11		
	CN3	30-pin SMD connector	SMD	SAMTEC	ZF1-30-01-T-WT	SAMTEC	ZF1-30-01-T-WT
	CN4	Power jack 2.5 mm	Socket, DC power, 2.5 mm, right angle, locking type	Protectron	PDCJ01-08		
	CN5	Terminal block, side entry, 2-way Pitch: 5.08 mm; mounting type: PC board;	2 pin terminal block, 5.08 mm pitch, orange color	Weidmüller	Weidmüller PM5.08/2/90	Farnell	Part# 1131853

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System overview

Table 4. BOM list (continued)

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code
<b>Capacitors</b>							
Capacitors	C1	Capacitor tant 47 $\mu$ F 6.3 V 20 % SMD	3216-18 (EIA) 1206	KEMET	T491A476M006AT	Digi-Key	399-3700-1-ND
	C2,C4,C8,C9	Ceramic capacitor 100 nF, 16 V 10 % X7R 0805	SMD0805	MuRata Electronics North America	GRM219R71C104K A01D	Digi-Key	490-1683-1-ND
	C3,C5	10 $\mu$ F, cap tantalum 10 $\mu$ F 10 V 20 % SMD	2012-15 (EIA) 0805	AVX Corporation	TAJP106M010RNJ	Digi-Key	478-3281-1-ND
	C6,C7	1 $\mu$ F, cap tantalum 1.0 $\mu$ F 10 V 10 % SMD	2012-12 (EIA) 0805	AVX Corporation	TAJR105K010RNJ	Digi-Key	478-3278-1-ND
LEDs	D2,D3,D4	LED, red color 8.8 MCD	SMD0805	OSRAM opto semiconductors Inc	LS M67K-H2L1-1-0-2-R18-Z	Digi-Key	475-2510-1-ND
Resistors	R4,R5	100 k $\Omega$	SMD0805	Any			
	R1	RES 180 $\Omega$ 1/8 W .1 % 0805 SMD	SMD0805	Susumu Co Ltd	RG2012P-181-B-T5	Digi-Key	RG20P180BDKR-ND
	R7, R8,R9	RES 470 $\Omega$ 1/8 W 5 % 0805 SMD	SMD0805	Panasonic - ECG	ERJ-6GEYJ471V	Digi-Key	P470ACT-ND
	R3,R6	RES 10 k $\Omega$ 1/8 W 1 % 0805 SMD	SMD0805	Stackpole Electronics Inc	RMCF 1/10 10 k $\Omega$ 1 % $\Omega$	Digi-Key	RMCF1/1010KFRCT-ND
	R10, R11, R12	0	SMD0805	Any			
	R2	RES 27 k $\Omega$ 1/8 W 5 % 0805 SMD	SMD0805	Yageo	RC0805JR-0727KL	Digi-Key	311-27KARCT-ND
Misc	Thermal printer	Thermal printer	Modular	APS	FM 205 - HS	Evolute	FM 205 - HS

## 4 Working principle of thermal printer

Printing on the thermal paper is done by rolling paper over the thermal head of the printer and then specific heat elements on the thermal head are heated through a given command. A black dot appears on the paper corresponding to the position of the heat element.

Each character is of size 16-dot\*24-dot. That is, each character is 16 dots wide and 24 dots high. So there are 384 dots for printing 1 character. One dot is equivalent to one bit of data.

The thermal printer used in this application supports printing a maximum of 24 characters in each line. Each line has 24 rows, as the height of the character is 24 dots. And, as already mentioned, each character is 16 bits wide. Therefore, the result is 16\*24 = 384 heat elements on the thermal head which are heated in the desired manner.

Data is printed row by row. As shown in *Figure 9* for character E, the first row of the character is shown as R1, which is printed first. This is the case with all characters in the line. This means that the 1st row of all the characters is printed first (16 bit). The hex value for R1 is 0x0000. Then, the stepper motor rotates two steps and R2 (0x3FFC in *Figure 9*) is printed.

**Figure 9. Font 'E'**

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16				
R1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
R2	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0				
R3	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0				
R4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R6	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R7	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R8	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R9	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0				
R10	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0				
R11	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R12	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R13	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R14	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R15	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R16	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
R17	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0				
R18	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0				
R19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
R20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
R21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
R22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
R23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
R24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				

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Then the stepper motor is rotated by 2 steps so that the printer head is pointing to the 2nd row. Now the printer prints the 2nd row of all the characters, and so on.

Similarly, when the 24th row is printed, the first line of data can be seen on the paper.



The character shown above can be interpreted in the string format as:

```
/* 'E' */
    0x0000, 0x3FFC, 0x3FFC, 0x000C, 0x000C, 0x000C, 0x000C, 0x000C,
    0x1FFC, 0x1FFC, 0x000C, 0x000C, 0x000C, 0x000C, 0x000C, 0x000C,
    0x3FFC, 0x3FFC, 0x0000, 0x0000, 0x0000, 0x0000, 0x0000, 0x0000,
```

These data to be printed are transferred to the printer through the SPI.

Then the stepper motor is rotated by 2 steps so that the printer head is pointing to the 2nd row. Now the printer prints the 2nd row of all the characters, and so on. Similarly, when the 24th row is printed, the first line of data can be seen on the paper. All the data to be printed can be first saved in character array.

Font data to be printed are dumped using SPI row by row and then a strobe signal is provided to the thermal head. When the strobe signals are given, the corresponding heat elements are heated and the result is that black dots can be seen on the paper. Then the stepper motor is rotated by 2 steps to write the data of the next row. After writing all the 24 rows, the writing of 1 line is completed. Here the stepper motor is rotated by 48 steps which provides a 1 line gap between successive lines.

Calculations for the delay between the successive steps of the stepper motor are:

- Paper movement speed = 0.0625 mm/sec (see FM205-HS datasheet, available from APS Industrial Srl)
- Max speed for the stepper motor at 5 V supply = 56 mm/sec (see FM205-HS datasheet)

This means the stepper motor of the thermal printer can move at a maximum speed of 896 steps per second. So delay between steps is 1/896, i.e. 1.11 mS.

To provide some safety margin, a delay of 2 mS between successive steps of the stepper motor is provided.

In this application, all the data to be printed is first saved in a character array of size 15. This means a maximum of 15 characters are printed in each row. Then the pointer to the base element of the array is passed to a function:

```
PrintData (pointer_ArrayBaseLocation);
```

In this function, a u16 type array variable, u16\_PrintDataArray, is updated with the fonts of a complete line using the fonts available from the microcontroller division. Therefore, the Nth row saves the Nth row of font values of all the characters. As each character is of 24-bit height, this array variable is of 24 rows and the number of columns is the same as the number of characters. As the maximum number of characters that the printer supports is 24, the number of columns of the array is also 24. After updating this array with font level information, the pointer to the base location of this array is passed to the function:

```
FM205Int (pointer_ArrayBaseLocation);
```

In this function, the font data is dumped using SPI3 row by row and then a strobe signal is provided to the thermal head. When the strobe signal is given, the corresponding heat elements are heated and the result can be seen as black dots on the paper. Then the stepper motor is rotated by 2 steps to write the data of the next row. After writing all the 24 rows, the writing of 1 line is complete. Here, the stepper motor is rotated by 48 steps which provides a 1 line gap between successive lines.



## Appendix A Definitions

**Table 5. Definitions of acronyms**

<b>Acronym</b>	<b>Definition</b>
PTVM	Parking ticket vending machine
PTVMDB	Parking ticket vending machine daughter board
MCU	Micro controller unit
LCD	Liquid crystal display
SPI	Serial peripheral interface
I2C	Inter integrated circuit
JTAG	Joint test action group
ESD	Electrostatic discharge

## Revision history

**Table 6. Document revision history**

Date	Revision	Changes
03-Sep-2010	1	Initial release.

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